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OBSERVATIONS ON THE GRYLLIDÆ: III. NOTES ON THE CLASSIFICATION AND ON SOME HABITS OF CERTAIN CRICKETS.

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CLASSIFICATION.

IN the course of collecting material for some cytological studies on the crickets, I was early confronted with the question of what are the true species of *Gryllus*. The first specimens collected I (*2*) called *Gryllus assimilis*, after carefully comparing them with the labeled specimens in the University of Kansas collection, and after reading such descriptions as were then available in the library. Later I collected about Chicago, Ill., and Woods Hole, Mass. My attempts at classifying these specimens led me to the conclusion that the species of *Gryllus*, the common larger field crickets, are not fixed but grade into each other. I found that in all of these places there were two groups with different breeding seasons—one that passed the winter in the nymph stage, and another that passed it in the egg. The former matures and breeds around Lawrance, Kan., during June and early July, and the other during the latter part of August and September.

This question of the true species in *Gryllus* was frequently discussed with my fellow student, Dr. F. E. Lutz, now of Cold Spring Harbor, N. Y., during our study at the University of Chicago. I am glad to confirm his recent publication (*14*) in which he says that the species of *Gryllus* as now named do not differ in characters, "but merely in the degree of common characters." My study has not been especially along the line

of taxonomic characters; but my attempts at classifying the specimens collected in Douglas and Harvey counties, Kansas, in Chicago, Ill., in Woods Hole, Mass., in the Santa Rita mountains, Arizona, and in Tarpon, Tex., trying to follow the keys given by Scudder, Blatchley, De Saussure and others, have led me to believe that Lutz is right when he says: "Either we simply name stages in a great continuous mass of variation and call them species or there is but one species of *Gryllus* in eastern United States, and the names we give are not the names of species at all, but simply inaccurate, shorthand expressions for recording the approximate size, proportions and color of individuals found." This applies to our common field crickets; and I do not think that it should be limited to the eastern United States, but should include the central portion as well.

On a collecting trip to Tarpon, Tex., last summer, I found a color variation which confirms this opinion that all these so-called species grade into each other. On the low sandy islands I found that the crickets were *straw yellow*. Most of them were in the last or next to the last nymph stage. This was about June 12. At first I thought they were the imported *Gryllus domesticus;* but later collecting disclosed some with a few, and some with many dark markings. A few of the adults taken subsequently were quite black. These were under the same boards or stones with the straw-colored ones, and were mating with them; and they probably came from the same mother. A number of nymphs were brought to the laboratory at Lawrence and raised to maturity. All of them turned much darker and some became jet black. As far as I could see these black ones could not be distinguished from our native species.

One peculiarity of these crickets on the islands at Tarpon offered an additional reason for thinking they were *G. domesticus,* or a closely allied species; *i. e.,* the young nymphs varied much in their stages of development, a peculiarity I had noticed in the domestic species in the greenhouses in Chicago. This fact must be due to the climatic conditions—both forms developing where there is a long-continued breeding season, with even temperature.

In the laboratory I found that these Texas forms mated very readily with our Kansas forms, both the spring-maturing and autumn-maturing broods. Some of the adults I brought with me paired with some tardy spring forms and some of the

smallest nymphs were not matured before autumn adults appeared.

In trying to classify these southern forms I finally concluded that they were our common black field crickets, which had lost *a little, very much,* or *nearly all* of their pigment. Although Blatchley, Scudder, and De Saussure use the color difference as one of the prominent characters separating species, I do not believe that it can properly be so used. "Black color" and "straw color" do not stand for different species in the crickets of the Texas coast. The black gradually shades off into the straw color; and a black one and a light one may have the same mother.

An examination of the germ cells reveals no differences in cell structure between the southern light-colored specimens and our native black ones. But both differ markedly from that found in *Gryllus domesticus,* as has been and will be shown by the papers dealing with spermatogenesis.

All of the collections made in the various localities show dimorphism as to wing length. The short-winged forms are very much more numerous in all places, but the long-winged forms vary greatly in frequency in the several localities, as Lutz (*14*) has found.

Blatchley (*6*) is correct when he suggests that the failure of past monographers of this genus is in part due to the fact that they have neglected the study of the animals in the field. By using this method he has added some very useful hints on the habits and structure, as they bear on the classification. He has plainly shown that there are in many localities really two broods, one maturing early and the other later. He considers them as belonging to different species. Lutz denies this. In whatever region I have observed the two broods, the autumn specimens are larger and more robust than the earlier ones. They also differ in proportions and color enough to represent two species according to ordinary criteria for species; but the intergrading of the forms from different localities would remove all distinctive characteristics. So while Blatchley is apparently right, I feel confident that extensive careful collecting will show that Lutz is correct.

The earlier brood lives "in burrows singly or in pairs," while the later ones "are more sociable," and there is not much "forsaking of burrows," as Blatchley (*6*) thinks. My observations have led me to the following conclusions: Of the

spring brood each individual has a separate well-made burrow, early in the season, usually under some stone or board. The male keeps his as long as he lives, or well through the breeding period at least; while the female abandons hers when she becomes an adult, or even before. Thereafter she may be found with the male in his burrow or in any convenient hiding place.

The young individuals of the autumn brood never make much of a burrow, but live under bunches of loose, dry grass or old rags, or whatever they find. I have frequently found more than a dozen in an old newspaper in the grass. The adult males sometimes have a sort of burrow, particularly late in the season, but most of the time I find them in any kind of a hiding place. I am quite sure, however, that these creatures, young and old, especially the males, have a selected spot in the grass or paper, which serves as their home, and so the difference between the spring and autumn forms is really this: the former dig a burrow for a home, while the latter simply select some convenient place to stay.

Judging from my study of the germ cells of *Gryllus domesticus,* given in a former paper (*3*), this species is quite different from the other forms. The difference of chromosome number and shape are such that I should expect the domestic species to be very different in taxonomic characters; but such is not the case.

In other genera of the family Gryllidæ the species are more distinct and limited. In *Œcanthus,* following Hart (*10*), we classify the species largely by the color markings on the basal joints of the antennæ, and this seems to be quite constant. I have found that I can separate the nymphs quite readily by means of these markings. *Nemobius* shows more variation, and probably after large, widespread collecting the species may prove to intergrade. In *Gryllotalpa* the species are quite distinct.

FOOD HABITS.

Very many observers have written of the food habits. It is known that the common black field crickets may eat almost anything. In captivity they will sometimes devour each other, the stronger ones feasting on the weaker ones even before they are dead. I have seen a female chew the wing of a male, and I have found a crippled female with her abdomen partly eaten away. In their free life I think this rarely or never occurs.

The females will eat the empty spermatophores whenever they find them.

Among the mole crickets I observed this peculiarity between two species. In a box of specimens of *Scapteriscus* sent me from Porto Rico I never discovered any partially devoured ones among the few dead specimens; but while collecting our own species *Gryllotalpa borealis,* in northern Indiana, I placed one female adult and six nymphs in a bottle full of sand in the field. When I returned to the laboratory I found but two nymphs, the others having been devoured by the adult. This, with some later experiences, led me to believe that adults will eat the nymphs whenever they find them in their burrowings. However, this cannot be true for the very young nymphs, as the eggs are laid in a mass in a much frequented part of the burrow, and the mother, no doubt, cares for the eggs and young for a while.

EGG-LAYING.

Blatchley (*6*) says: "The eggs of most crickets are laid singly in the ground." My observations confirm this as far as *Gryllus* and *Nemobius* are concerned. The large black field cricket selects usually a somewhat barren spot in a grassy field, where she lays her eggs. She will force her ovipositor into the ground and deposit a single egg, then removing the ovipositor partly will put it down at a different angle and plant another egg, and repeating the process will leave a third. On no occasion did I see more than four eggs laid without the ovipositor being completely removed and pushed into the ground at a new place. *Nemobius* lays its eggs in a similar manner. Two or three, rarely four, eggs are laid almost side by side, and then the next batch are placed a quarter of an inch or more away.

In but one instance did I find eggs laid by the mole cricket. They were "in a heap on the floor in the enlarged part of a side gallery," just as Barrett (*1*) has described.

CHIRPING.

A peculiar habit of the mole crickets, of which I made brief mention in an abstract (*4*), is the *chirping of the female.* A hurried examination of the tegmina of the females will show that the nerves are modified into a rasping and sounding organ, which is not as large or as well developed as that of the male, but well enough to have made thoughtful observers of the past

suspect that it might function, and that female *Gryllotalpa* might chirp. As far as I have been able to read the literature no one has observed that they actually do so. Most of our books say that only the males stridulate. LaCordiare (*12*) says, "The chirping organs of the crickets are simple and limited to the males." Scudder, speaking of the crickets, says, "his egotistic love song." Comstock (*7*) writes, "the males of the crickets have musical organs." Lang (*13*) says: "In the Locustidæ and Gryllidæ only the males stridulate, by rubbing the rough basal portions of their wing cases against each other." Packard (*15*), after speaking of the organs in the males, says: "The females are not invariably dumb, both sexes of the European *Ephippigera* being able to faintly stridulate." Henneguy (*11*), in speaking of the musical organs, writes: "Where they are found they are well developed in the males only; in the females they are more or less rudimentary. Such is the case in the Gryllidæ." Barrett (*1*) describes the stridulating organ in the male "Changa" or Porto Rican mole cricket, *Scapteriscus didactylus;* but he has completely overlooked the same but less well developed organ in the female.

The female mole cricket has quite a loud and distinct chirp. It usually consists of a single note; but there may be several at short intervals. This note is less shrill than the ordinary call of the male. However, the male has a note very similar to that of the female which it uses for the same purposes, namely, as a means of recognition in the dark burrows. The call is always given when one individual is approaching another, especially when digging a new tunnel. Both genera, *Gryllotalpa* and *Scapteriscus,* have the stridulating organ on the female elytra, and so both must be able to chirp. I never isolated a Porto Rican female to hear its chirp, but after hearing the call of our native cricket I feel sure that I have heard the insular female's chirp also.

This unusual ability possessed by the female is an adaptation to life in underground burrows. It enables the individuals to recognize others which are approaching under conditions where sight cannot be used. Thus enemies and friends can be distinguished; while if the female were dumb, as she is in all other crickets as far as I know, they might often attack even their mates.

PROTECTIVE GLANDS IN THE MOLE CRICKETS.

As indicated in an abstract (*4*), I have found that the correct interpretation of the function of the anal gland, which has so long puzzled investigators, is protective. Leon Dufour (*8*), a careful French investigator, first described in the mole crickets in both sexes a pair of azure or skim-milk colored glands connected with the rectum. Their secretion he compares in consistency with the vitreous humor of the human eye. To this secretion is added some excrement from the rectum, and when this mixture is expelled it forms a brown liquid of nauseating fetidity. He calls the gland "an organ of excremental secretion."

Berlese (*5*) describes the same structure and thinks it is a prostatic gland analogous to that found in the locustids. Although he found it in the female also, he does not seem to try to explain it there.

Fenard quotes both of the above descriptions and adds a good many observations of his own. He describes the gland from sections and gives the action of certain fixatives and stains upon the tissues of the gland and its contents. He states in detail the macroscopic and microscopic structure. He concludes as follows: "Judging from the position of this organ, from the consistency of the liquid which it contains, and from its points of similarity with the prostatic glands of the locustids, I think that it ought to be considered also as a gland furnishing a mucus destined to lubricate the copulating apparatus. This organ exists in the female, it is true, but in this case it furnishes without doubt still a lubricant for the vagina, or a liquid to form the nest of these insects." After describing the details of this gland in the female he says: "I think that these organs can only be some secreting agent of a mucus destined to lubricate the genital organs; or perhaps they glue together and hold the spermatophores; or perhaps again they secrete the substance used to form the nests in which are found, as we all know, two to three hundred eggs all massed together and more or less united." It is evident from this uncertainty that Fenard did not know the function of the glands in question, yet he was inclined to follow Berlese and called them "prostatic glands."

Packard, in his work on Entomology, places the anal odoriferous glands described by Dufour among the repugnatorial

glands, apparently because he has concluded that all fetid and anal glands are repulsive.

As far as the position, size and structure of these glands are concerned, these earlier observers are on the whole correct. They agree, too, in the main points. Dufour has the glands attached to the rectum, while Fenard has them attached to the genital duct. The explanation of this difference of observation is partially suggested by Fenard, when he says: "En somme ces organes paraissent d'eboucher dans une sorte de cloaque ou arrive l'oviducte." The mole crickets have but a single opening at the posterior end of the abdomen; and a short common duct carries the genital and excrementary products. This should very properly be called a "cloaca." Into this cavity the short ducts of the anal glands empty.

Fenard gives as the sizes of the glands "about six millimeters in length and three millimeters in thickness." I found none as large as that, but the size would depend in part upon the amount of secretion in the gland. Both Dufour and Fenard speak of two lobes and a median constriction. There is some tendency for such a constriction to show, but it is not constant. The shape and position of the organ would depend somewhat on the amount of extension of the abdomen and the fullness of the rectum. The two lobes when present do not differ in histological structure, and not in function, as Fenard has shown by his careful work by means of sections. The walls are resistant, the cavity large, and the contents appear homogeneous, granular, and they coagulate as a result of fixation, and color strongly whenever stained. All these facts Fenard has correctly described.

But Fenard must have worked with preserved specimens only, or he would not have made the error concerning the function of the gland. Although he quotes Dufour, he cannot have followed his suggestion when the latter says: "If one seizes a mole cricket of either sex, it squirts from the anus a brown liquid of nauseating fetidity. This liquid is formed in part by excrement from the rectum and is in part the product of a special secretion."

I have studied *Scapteriscus didactylus* from Porto Rico and *Gryllotalpa borealis* taken in northern Indiana and in eastern Kansas. My observations and experiments show that the above quotation is correct in most parts. If the insect is held or irritated in the region of the head or thorax, there is no discharge.

But if held or pinched or pricked or chemically irritated on any side of the posterior part of the abdomen, or on the hind legs, there is always ejected from the anus a bluish-white liquid with some excrement. The discharge is directed as nearly as possible to the point of attack, be it above, below, behind, or on either side of the abdomen. It is driven with considerable force, enough in some instances to carry it across an aquarium eight inches in diameter. After several ejections there is less excrement in the liquid, which becomes almost colorless, losing its milkiness.

The ejected mass has a very fetid odor and is *very sticky,* so sticky that a half-grown nymph can readily be suspended by lightly touching a needle to some of the secretion and then to its abdomen. An adult female, in spite of her strong legs, was held for nearly a minute as a result of touching her besmeared body against the side of the jar.

In some breeding experiments reported elsewhere I was able to study the effect of this ejection and the conditions under which it is made. There was no discharge when the male was carefully introduced into the jar with the female, but on one occasion it happened that the male became excited and rushed upon the female in his attempt to get away. He received a discharge upon his head and into his face. He stood for a long time trying to clean this off. He apparently could remove but little of it, and died on the second day thereafter. At another time a female received a lesser discharge from a male. She, too, spent hours trying to scrape off the sticky stuff, but failed, and died on the third day. The other pair lived for many weeks longer. Perfectly calm individuals, when put into a jar in which there had been a discharge a day or so before, became very much agitated and tried hard to escape from the enclosure. This behavior suggests that when these insects get this odor it warns them that an enemy has been or is near, and they try to escape. I repeated this test several times with the same result. I introduced some affected sand into a jar containing a calm individual. He became agitated. In every instance the crickets became excited when they perceived the odor.

The fetidity of the liquid must repel very ardent pursuers, and the stickiness must retard them should they become entangled in a discharge. It is, no doubt, for the purpose of so entangling the enemy that the cricket directs its discharge toward the point of attack.

This defensive organ probably explains the fact that mole crickets have so few natural enemies, as reported by Barrett (*1*).

Since the Gryllotalpidæ move most of the time in underground burrows the discharge from the anus would protect against attacks from the rear. Hence there is no discharge when the irritation is on the anterior half of the body. The head and thorax, besides being very hard, are further protected by the powerful fore legs. The abdomen is comparatively soft and without other protection than that described above.

My observations and experiments prove conclusively that the secretion of the anal glands, or "prostatic glands" of Berlese and Fenard, is preëminently protective, as any one who will take the trouble to secure a live specimen and repeat these tests can see for himself. Neither Berlese nor Fenard can have handled live individuals, or they should have seen the use of the anal secretion.

As far as we know no other orthopteran has these protective glands, nor has it the same peculiar habits. The mole crickets running along the narrow underground tunnels have the soft abdomens constantly exposed to the attacks of enemies which they cannot see or perceive, so they have developed a special organ which can instantly repel or retard a pursuer.

SUMMARY.

1. The species of *Gryllus* in eastern and central United States are not distinct, but form one large intergrading series, as Lutz has shown. This is true also for the supposed distinguishing *straw* and *dark* colors as shown by the specimens collected in Texas.

2. The female mole cricket has a partially developed chirping organ on its elytra. With this instrument it produces a single note used as means of recognition in the dark tunnels.

3. The anal gland of Dufour, the prostatic gland of Berlese and Fenard, is protective in function. The secretion operates as a repellant by its fetidity, and as a retardant by its stickiness.

4. Both the female musical organ and the protective gland are adaptations to life in underground tunnels.

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